**NUST Institute of Civil Engineering (NICE) SCEE, NUST**

# Final Year Project Thesis

**To Develop 5D Model of School of Mechanical & Manufacturing Engineering(SMME ) West Wing Building in National University of Sciences and Technology(NUST) H-12 Islamabad & Use of Building Information Modeling(BIM) for Facility Management.**



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| **Shabana Batool** | **2011-BE-CE-136** |
| **Ibtehal Mehboob** | **2011-BE-CE-133** |

# ABSTRACT

The project we did was basically aimed to implement building information modeling technology and associated set of processes to design, produce and analyze our building model. We did literature review from different books and research papers to understand BIM and its applications especially for facility management of building. For this purpose we have deliberately read many articles, books and documents related to BIM. The information and data that we have obtained, helped us in implementing BIM in our model more effectively and to practice facility management using BIM. It helped us to create better understanding about the benefits and problems related to BIM and its implementation. BIM implementation in our project was mainly aimed to form the 3D, 4D (scheduling), 5D (cost estimation) and energy efficient model of our building along with digital database and covering the facility management of the building. Nowadays as BIM is getting more and more attention from the construction related industries and firms, it is essential to know what BIM is?. How is it useful for the construction projects? Why it should be implemented? How it can be implemented in a project? We have mostly consulted from the articles published by BIM experts on authorized websites of internet and books wrote on BIM.100% implementation of BIM in any project is very difficult because of the complexity and lack of knowledge.. So, it was difficult to implement BIM 100% for us but we tried our best to learn all aspects of BIM by modeling our building using the available data and software related to BIM, but as BIM is mainly developed for large projects which involve architecture, design and construction firms so we focused on the modeling of building using software especially Autodesk Revit and Neviswork and worked on facility management in our project by learning different case studies.

**Copyright Notice :**

## Dedication:

**We dedicate our work to our parents, teachers, friends ,family for supporting us and especially our supervisor Dr. Jamal Thaheem who guided us throughout the project.**

# INTRODUCTION:

## PROJECT STATEMENT:

To Develop 5D Model of School of Mechanical & Manufacturing Engineering(SMME ) West Wing Building in National University of Sciences and Technology(NUST) H-12 Islamabad & Use of Building Information Modeling(BIM) for Facility Management

## Project Description:

Our project was to create 5D Model of the building of NUST **SMME West Wing** which was under construction at the project selection time**.** We also had to use the model we created for the facility management of the building. **S**o for 3D modeling purpose we used Autodesk Revit and for 4D and 5D WE used Autodesk Neviswork, we also had to perform the energy analysis of the building.

## PROJECT SCOPE:

The building which we modeled in our project was under construction , so the model we created will help to evaluate constructability and design intent before the completion of construction. The model will facilitate the facility managers of the building to use the model for doing the maintenance and repair works in future in the operation phase more quickly and efficiently. The energy analysis simulation results of the building which we got from ecotect software will help the facility users to optimize the energy consumption in building.

### Project challenges:

The project building which we modeled was firstly designed for SMME classrooms but after construction started it was a shared building between SNS and SMME converting some classrooms to labs, so additional MEP work was required.

## 3. LITERATURE REVIEW:

**3.1 Background:** Building Information Modeling is a process focused on the development, use and transfer of digital information model of a building project to improve the design, construction and operations of a project.

In reality, the processes and technologies behind BIM have been evolving for at least 40 years. Early researchers included Chuck Eastman (then at CMU, now at Georgia Tech), Tom Maver at Strathclyde University, Arto Kiviniemi in Finland (now at Sanford University), and John Mitchell and Robin Drogemuller (QUT) in Australia. Eastman's 1975 paper "The use of computers instead of drawings in building design" described a working prototype "Building Description System (BDS)", which included ideas of parametric design, deriving 2D drawings from a model, a "single integrated database for visual and quantitative analyses" and he also suggests that "Contractors of large projects may find this representation advantageous for scheduling and materials ordering Comparable research and development work was conducted in

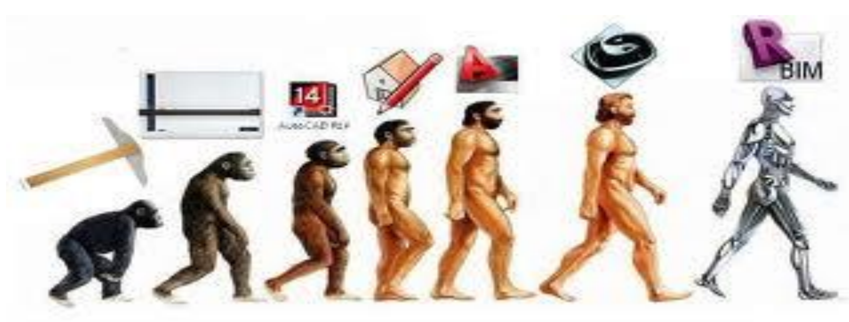



**Figure 1 :Revolution of BIM**

1970s and early 1980s in Europe—especially in the UK—in parallel with early efforts at Commercialization of this technology. During the early 1980s this method or

Approach was most commonly described in the USA as "Building Product Models" and in Europe—especially in Finland—as "Product Information Models" (in both phrases, "Product" was used to distinguish this approach from "process" models). The next logical Step in this nomenclature evolution was to verbally factor out, so to speak, the duplicated "Product" term, so that "Building Product Model" + "Product Information Model" would Merge into "Building Information Model."In the 21st century, every evolution in technology has been achieved with advances in computer science. The result of each evolution is to provide more information to attain objectives easily. This technical evolution is also reflected in the Architecture, Engineering, and Construction (AEC) Industry. In the past 10 years, de-sign tools in the AEC industry have been improved from 2D modeling to 3D modeling by the use of BIM.

## 3.2 What is BIM?

***"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition"***

Traditional building design was largely reliant upon two-dimensional drawings (plans, elevations, sections, etc.). Building information modeling extends this beyond 3D, augmenting the three primary spatial dimensions (width, height and depth) with time as the fourth dimension (4D) and cost as the fifth (5D), etc.BIM therefore covers more than just geometry. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components (for example, manufacturers' details).

Building Information Modeling (BIM) is the process and practice of virtual design and construction throughout its lifecycle. It is a platform to share knowledge and communicate between project participants. In other words, Building Information Modeling is the process of developing the Building Information Model. "BIM is a modeling technology and associated set of processes to produce, communicate and analyze building models".(BIM-Handbool-1st edition)

BIM has its roots in CAD research from decades ago, yet it has no single or specific widely accepted definition. Different people define it differently. Some think of it as" an intelligent simulation of architecture", some called it a methodology for managing project by use of modeling and information techniques". IDEAL BIM has every fact and data expressed only once in a master model for possibly derived models. The model requires the drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions, (emissions data) and submittal processes all work together. The whole process is about different information resources feeding into the documentation, which then becomes a necessary part of the model. A BIM (Building Information Model) carries all information related to the building, including its physical and functional characteristics and project life cycle information, in a series of "smart objects"

## 3.3 How BIM Works????

The term 'BIM' is mistaken for the software platforms such as AutoCAD MEP or Revit that have BIM capabilities.BIM is a strategy to assemble your building design, while Revit, AutoCAD MEP and Neviswork are tools to help create and troubleshoot the models. Many people think BIM is software which is a misunderstanding because BIM is a technology which uses software's and tool to make an ideal building information model.

BIM can be implemented in IPD projects very effectively. Because BIM requires coordination between the different participants of the project from the beginning of planning phase.

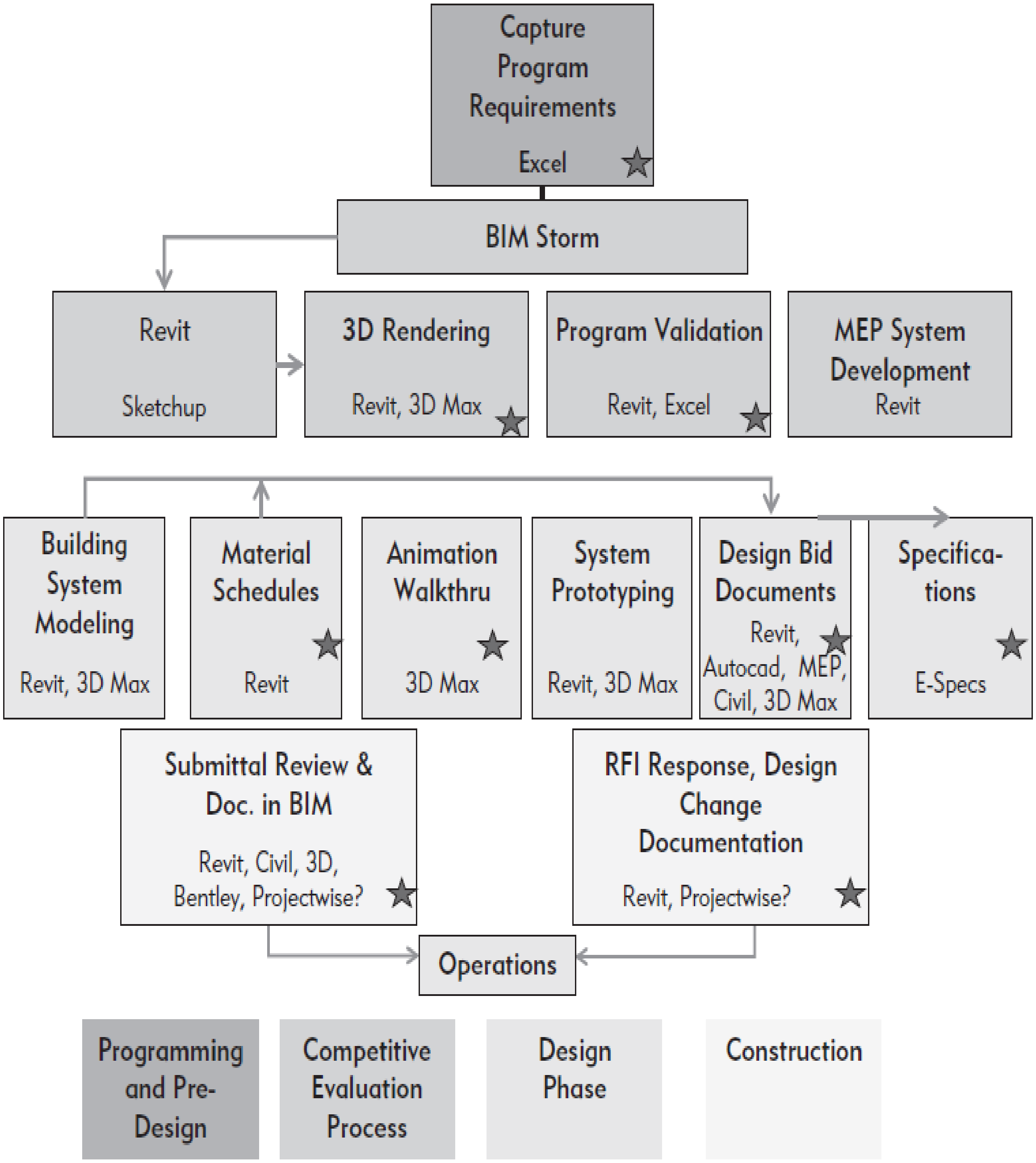



**Figure 2 How does BIM Coordinate?**

## 3.4 BIM Uses:

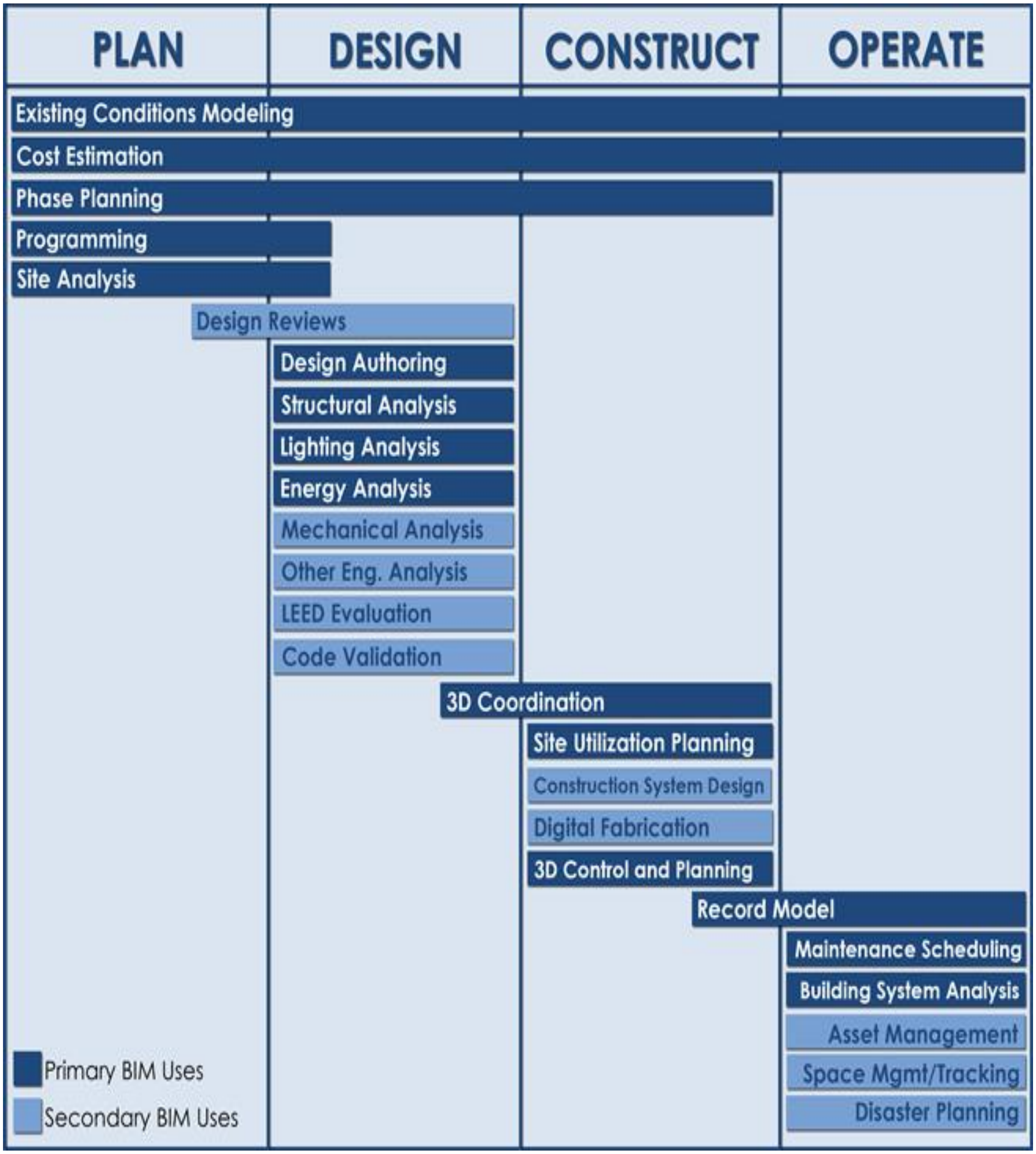



Figure: 3 BIM Uses

## 3.5 BIM Applications:

**3.5.1 Visualization:** 3D renderings can be easily generated using different soft wares.

**3.5.2 Fabrication/shop drawings**: it is easy to generate shop drawings for various building systems, for example, the sheet metal ductwork shop drawing can be quickly produced once the model is complete.

**3.5.3 Code reviews:** the digital database is used by different department like power, fire and etc for the review of building for various purposes.

**3.5.4 Facilities management**: facilities management departments can use BIM for renovations, space planning, and maintenance operations.

**3.5.5 Cost estimating:** BIM software(s) have built-in cost estimating features. Material quantities are automatically extracted and changed when any changes are made in the model.

**3.5.6 Construction sequencing:** a building information model can be effectively used to create material ordering, fabrication, and delivery schedules for all building components.

**3.5.7 Conflict, interference and collision detection:** BIM models are created, to scale, in 3D space; all major systems can be visually checked for interferences. This process can verify that piping does not intersect with steel beams, ducts or walls.

**3.5.8 Green and sustainable buildings:** BIM can help a lot in building Green and sustainable buildings as its master model can be used to analyze the performance of building in future. For this purpose a new concept of green BIM is being used now.

**3.5.9 Energy analysis**: The BIM-based analysis tool “ECOTECT” can perform a detailed analysis of energy performance of the whole building.

BIM is used in many A/C firms by architects, engineers, constructors, designers and material suppliers. Many green building project teams use BIM because BIM facilitate green design, construction and sustainability.

## 3.6 BIM Benefits:

The key benefit of BIM is its accurate geometrical representation of the parts of a building in an integrated data environment. BIM enables better decisions; faster BIM reduces the abstraction and integrates the multiple disciplines, including design and documentation.

**3.6.1 In design phase:** BIM could improve the design phase. For example, the architects can use BIM to make any change at any time without any difficult process, hard harmonization and manual checking work.

**3.6.2 In construction phase:** BIM also improves the process of construction, project documents and the relationship between clients and architects. BIM could reduce the construction time and reduce the spending on operation and overhead cost.

**3.6.3 In management phase:** In the management phase of the building lifecycle, building information modeling makes available concurrent information on the use or performance of the building; its occupants and contents; the life of the building over time; and the financial aspects of the building.

**3.6.4 In operation phase:** Building Information Modeling creates obtainable concurrent information on performance of the project; and the economic aspects of the project. BIM leaves a digital document trail resulting from transformations and developments during operation.

**3.6.5 Digital data record:** Building information modeling provides a digital record of renovations and improves move planning and management. Whenever a change is made to a project, all the consequences of that change are automatically coordinated throughout the project. This allows the design team to deliver better work.

**3.6.6 Faster and more effective processes:** Information is more easily shared, can be value added and reused.

**3.6.7 Better design:** building proposals can be rigorously analyzed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions.

**3.6.8 Controlled whole-life costs and environmental data:** environmental performance is more predictable, lifecycle costs are better understood.

**3.6.9 Better production quality**: documentation output is flexible and exploits automation. . The automatic coordination of changes offered by building information modeling eliminates coordination mistakes, improves the overall quality of the work,

**3.6.10 Automated assembly:** digital product data can be exploited in downstream processes and be used for manufacturing/assembling of structural systems.

**3.6.11 Better customer service:** proposals are better understood through accurate visualization.

**3.6.12 Lifecycle data requirements:** design, construction and operational information can be used in facilities management

## 3.7 BIM Barriers:

Building information modeling (BIM) is slowly changing the way building projects are approached, though it is more efficient than the older techniques being used in construction processes.

**3.7.1 Expertise:** There isn't a ton of BIM expertise out there especially in the home building sector. It is a relatively new technology and can be complicated to grasp, so there tends to be a natural reluctance to take BIM on.

**3.7.2 Software cost:** The initial costs for hardware, software, training, and implementation can be very costly.. This perceived cost and risk of spending money before actually saving any can be a turn-off for first time BIM users.

**3.7.3 Workflow control:** Keeping tabs on and controlling input into a BIM model can be a daunting task. Many different parties must be able to use the model, so access protocols are a must. Finding a BIM manager can be tough, though, as the person in that position assumes a large amount of risk and requires expertise in a niche field.

**3.7.4 Version management**: Constant up gradation of software has been an issue for the practitioners. While most often upgraded softwares allow using data generated from earlier versions, many a times significant changes inhibit these.

**3.7.5 Organization and data management:** As more and more data is managed and stored electronically standard practices and procedures need to be in place to deal with data organization, storage and security. Managing the different versions of the project, which r elates to compatible set of data from different disciplines at specific stages need to be fixed.

**3.7.6 Architectural training in schools:** one of the major criticisms of the architectural education in the recent years has been the widening gap of the techniques and methods taught in architecture schools and what is practiced in the field. Rather than giving separate introductory sessions on computational approaches and BIM applications there is a need for integrating the same in design studios for the students.

**3.7.7 Security of data**: Putting data on an integrated database in an electronic format raises some security concerns amongst the involved players. Related to it are the concerns of Intellectual Property (IP) and protection of copyrights. While some concerns on network security from a technical viewpoint may be justified, others may be alleviated by greater awareness and legal measures.

**3.7.8 Readiness of the tools:** Examples of the use of BIM approach in practice suggest that in th e present state as well there are tools that can significantly improve the work process in the AEC industry. However, lack of tools supporting and integrating conceptual design activity has been a major concern.

### 3.8 BIM Vs. 2D/3D CAD:

BIM is not the same as the well known computer-aided design(CAD)technology.BIM goes further than a tool to generate digital(2D or 3D) drawings. The principal difference between BIM and 2D CAD is that the latter describes a building by independent 2D views such as plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major


**Figure 4 BIM Vs.CAD**

causes of poor documentation.BIM is qualitatively different from CAD because it is not just a depiction, but it is an object-based definition of the facility. The information maintained in a BIM is also different from the type and level of information maintained by CAD. Rather than drawing lines that describe dimensions of a design, with BIM designers organize intelligent objects into a design. There is a design analysis also so BIM is not design documentation only like CAD.

## 3.9 BIM Implementation in World and Especially in Pakistan:

BIM use is growing in most countries like Singapore, Japan, UAE, US, India and in the Nordic countries. . Some firms use BIM only for architectural design, some use it for green building, some use it for 3D modeling of building. But these are some functions of BIM, if we integrate these all and many other functions of BIM then we can say that BIM is implemented throughout the project.

Singapore was one of the earliest countries to realize the potential of model-based design, and this was before the term BIM was even introduced. China is indirectly advocating the use of advanced AEC technologies like BIM, even though it is not mandating BIM outright. In contrast to most countries, the UK Government has actually mandated the use of BIM. In May 2011, the UK Cabinet Office published a "Government Construction Strategy" document that has an entire section on "Building Information Modeling," within which it specifies that Government will require fully collaborative 3D BIM as a minimum by 2016. The Nordic countries of Norway, Denmark, Sweden, and Finland are home to some key AEC technology vendors such as Tekla and Solibri, and also rank high in the adoption of ArchiCAD that originated from neighboring Hungary. In the US, the official use of BIM is synonymous with the GSA's BIM initiatives. The GSA (General Services Administration) is responsible for the construction and operation of all federal facilities in the US, and in 2003, it established a National 3D-4D-BIM program through the Office of the Chief Architect of its Public Buildings Service.

Most of the medium to large architecture firms in Pakistan have at least a basic understanding of BIM. BIM is understood in Pakistan as a design approach that involves data sharing between all the consultants involved in a building project, and the development of an integrated building model which houses this information and can be used for developing BOQs and schedules. Although the concept of BIM is relatively well-understood by the more prominent architectural firms in Pakistan, it has not received broad acceptance as a design approach. Architects use BIM software like ArchiCAD, AutoCAD and Revit, but the main emphasis is on modeling building skins to review the design in various manifestations of composition, color, texture and materiality. Building Information Modeling is gaining ground in Pakistan as a design approach due to several factors. Architectural firms that want to employ the BIM design approach and clients that want to gain from the additional information, accuracy and integration must come to a compromise and agree to develop the BIM in various stages and with varying level of information.

# 4. Pre Modeling Phase:

## 4.1 Reason for the selection of project:

As BIM is the emerging technology (being used by engineers in most parts of the world), which is going to be the future of construction industry. As civil engineers it is important for us to learn the modern and efficient techniques of structure design and analysis. We can compete the world only if we learn the modern technology, to make ourselves capable of understanding and implementing new technologies in our building projects, we have selected this project, to see and analyze the benefits and issues related to BIM by creating and analyzing our model. Our subject of interest in future and present is construction management, so as students of building construction management it is essential to know the modern techniques of construction management. BIM provide many strong management tools like scheduling, cost estimation, coordination between different teams involved in the project.

1. We have selected the building of NUST SMME to model because the building is located in NUST and more important reason is that it is under construction. So we can make practical use of our Building Information Model and can see the difference by comparing our model results with the actual ones.
2. As facility management of buildings is an ignored area in construction management so we decided to learn about the use of BIM for facility management of building and application of the learning in our model.

## 4.2. Data collection and Drawings:

All the drawings and data required for the completion of the project was taken from PMO NUST.

## 4.3. Attributes of the building:

| | |
|---|---|
| Location: | NUST H-12 Islamabad. |
| Purpose of the building: | School & University |
| Topography: | mix of flat and sloped terrain |
| Building Orientation: | angle of true north 157.000° |
| Floor areas: | 15,634 sf |
| Planned start date: | 5th September 2013 |
| Planned finish date: | 28th February 2015 |
| Actual finish date: | 14th May 2015 |

## 4.4. Software required for modeling of the building:

- **Autodesk Revit**
- **Autodesk Neviswork**
- **Autodesk Ecotect**
- **CAD to Earth**
- **MS project**

**Geographical Location:**


Figure:5 Google imagery of the site of building

# 5. Detailed Modeling Approach of the building:

## 5.1 Architecture Model Approach:

We started with modeling the architecture of the building.

- Toposurface imported
- Set the orientation of the toposurface and the site
- Levels,grids and reference lines were created.
- Walls,ceiling and roofs for different levels were created.
- Windows,doors and other host based elements were inserted.
- Interior,lightening and furniture layout was done.

Fig 6: Front view

**Figure: 7 East exterior side of the building**

**Figure 8: East corner view**

Figure 9: Back side of the building

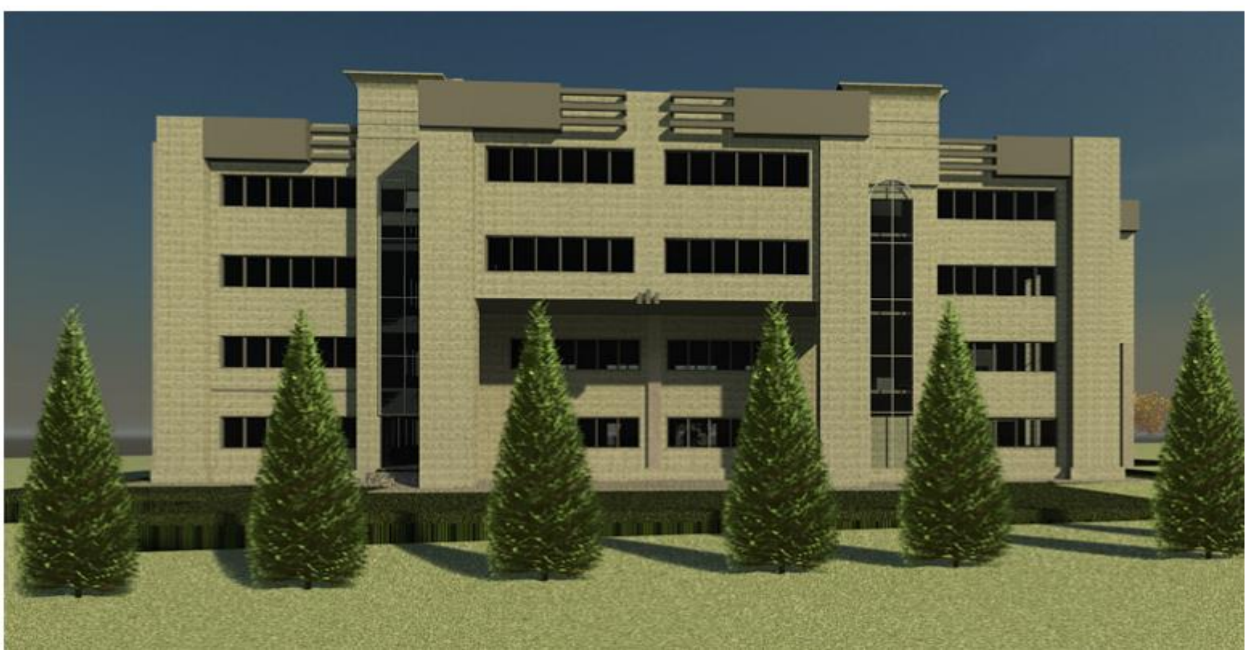


Figure 10: First rendered image of SMME west wing

## 5.2 Structural model Approach:

- Linked architectural model in revit structure model
- Used the grids,levels and reference planes created in architectural model and created the foundation plan.
- Created the frame of structure beams and columns.
- Created the roof and the roof slabs.

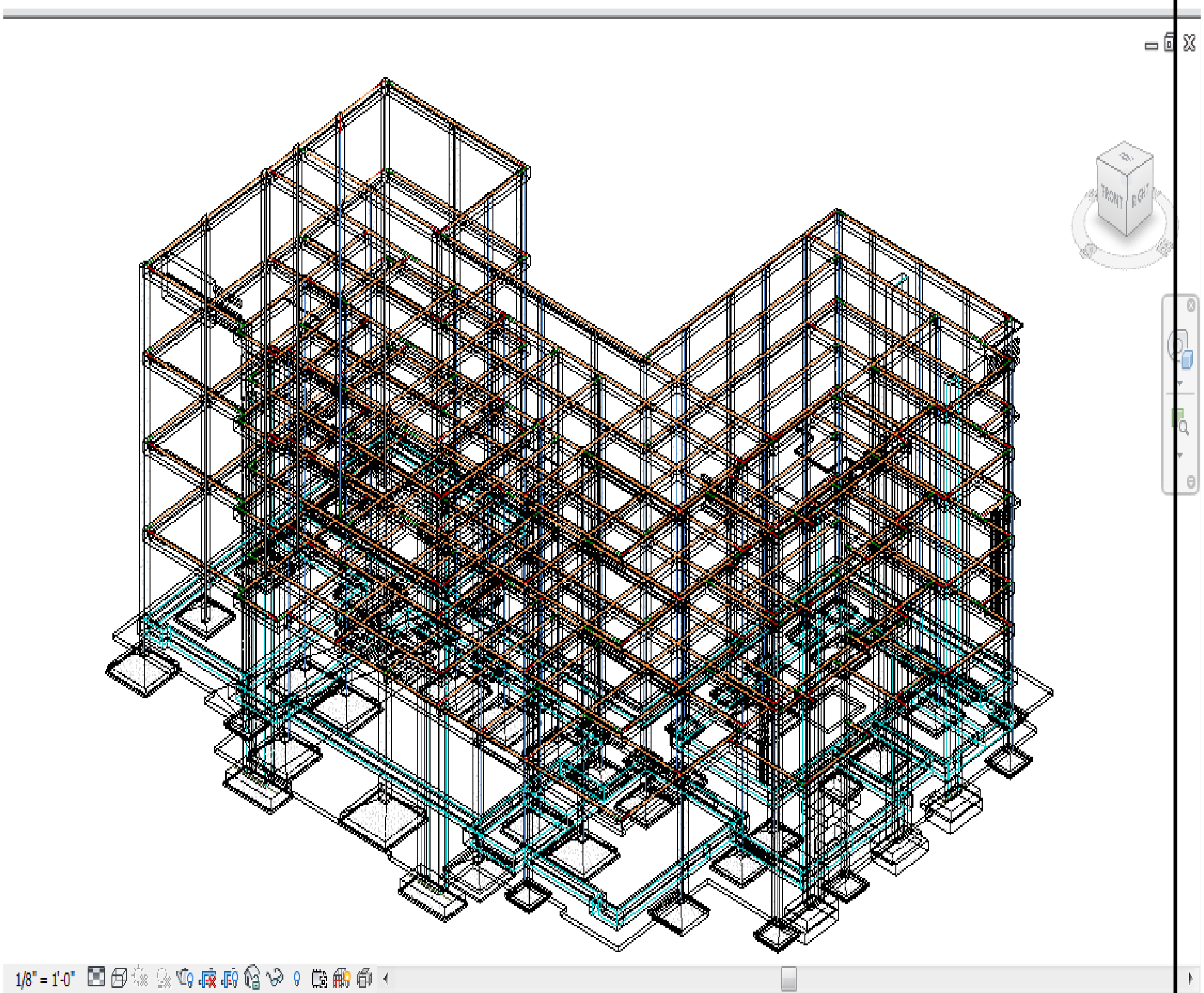



Figure 11: Structural wireframe view:

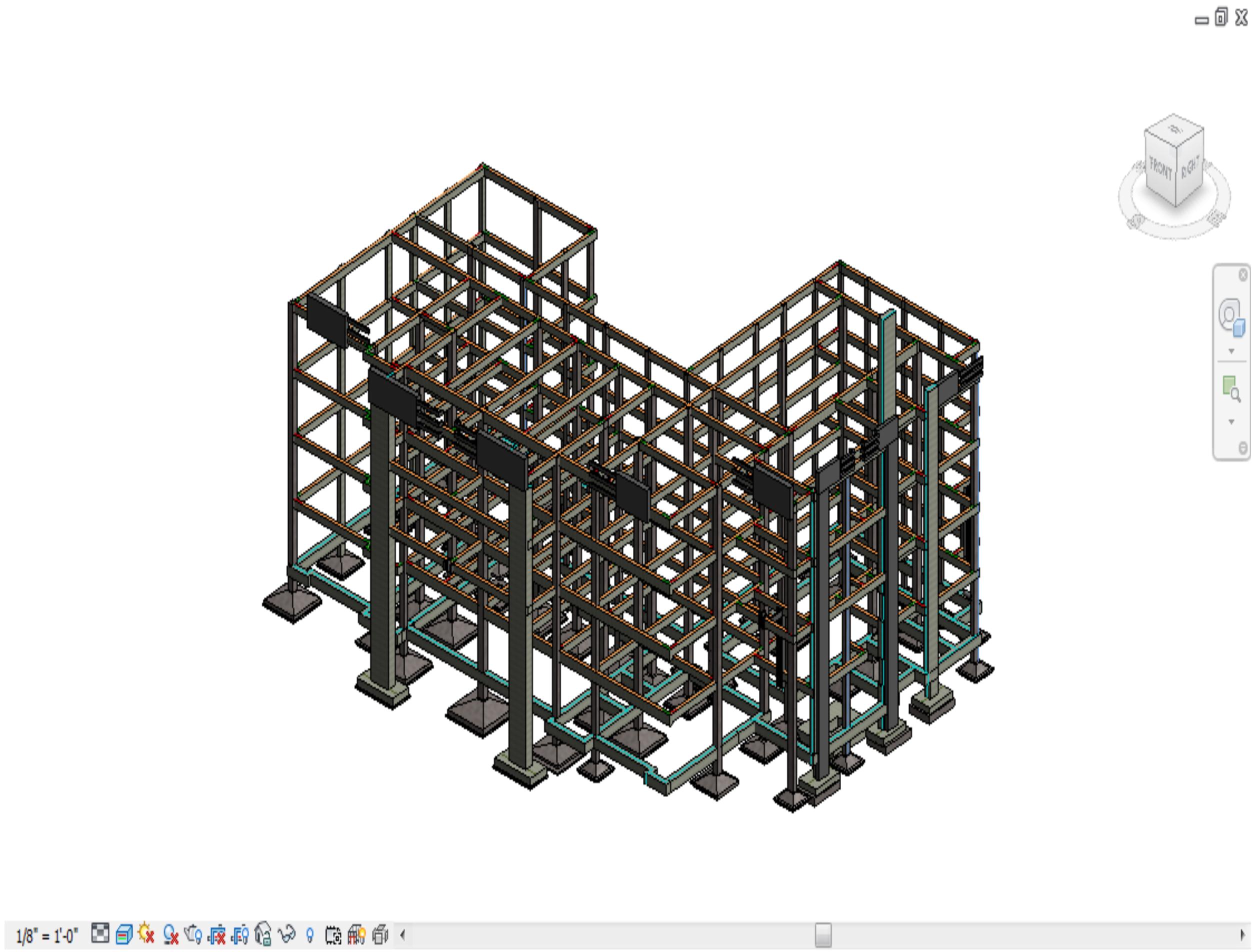



Figure 12: Structural frame model

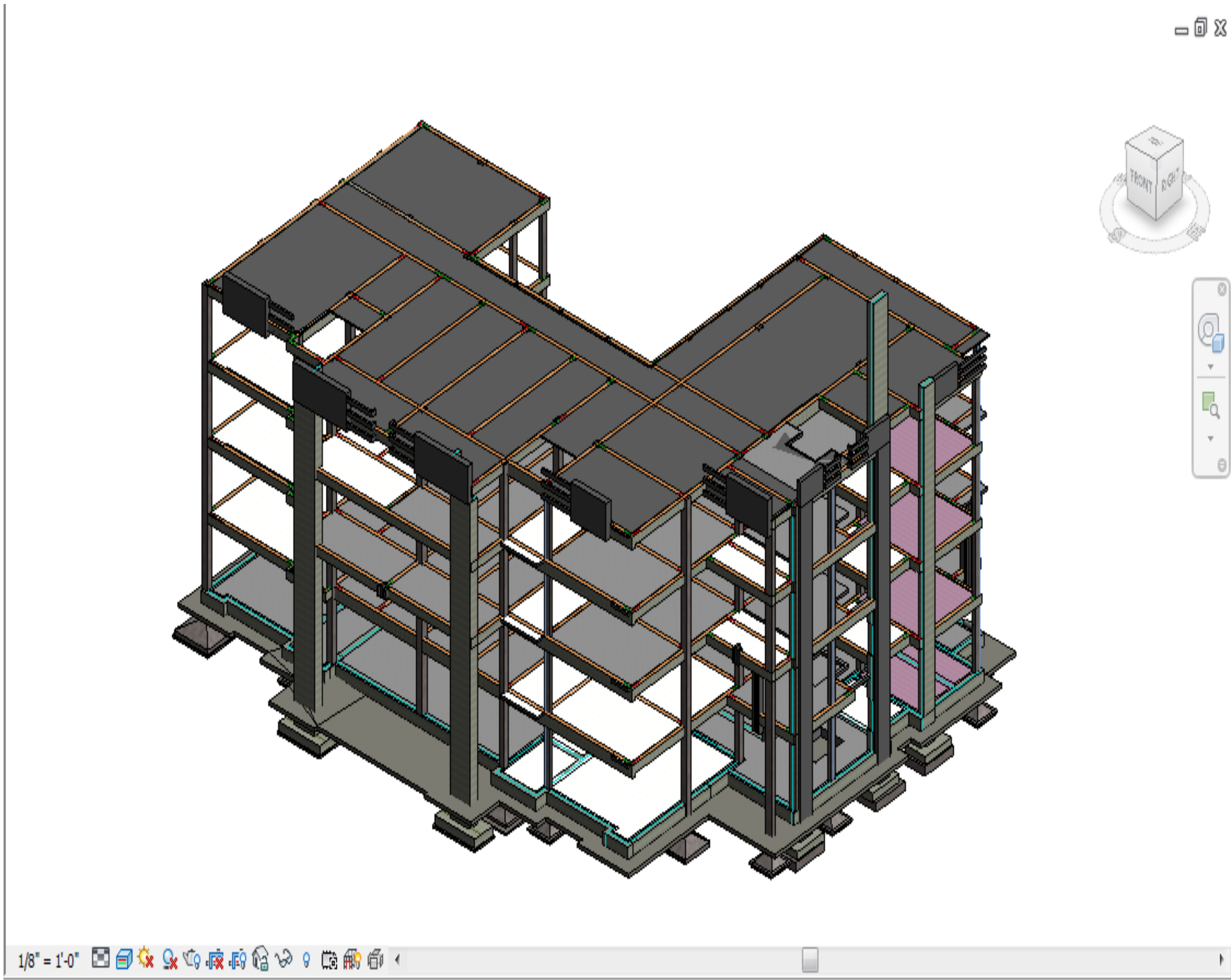



figure 13: Structural 3d image

## 5.3 Interior:

Figure 14: Interior furniture setting with lighting

Figure 16: Interior of lab furnished with lighting

## 5.4 MEP Approach:

- Link architectural model into MEP Revit software
- Used the same levels, grids and reference lines created in architectural model
- fixed the electric and plumbing fixtures.

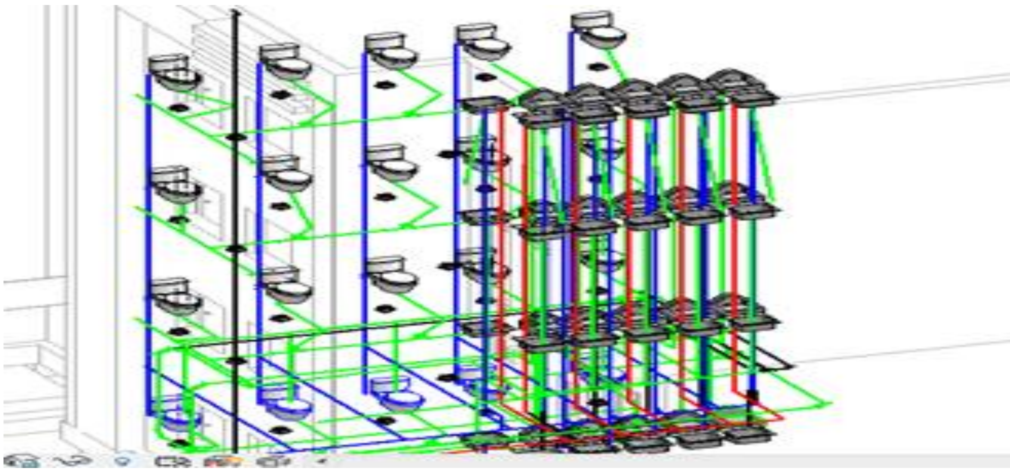


Figure 18:Plumbing fixture and pipes layout in 3D View

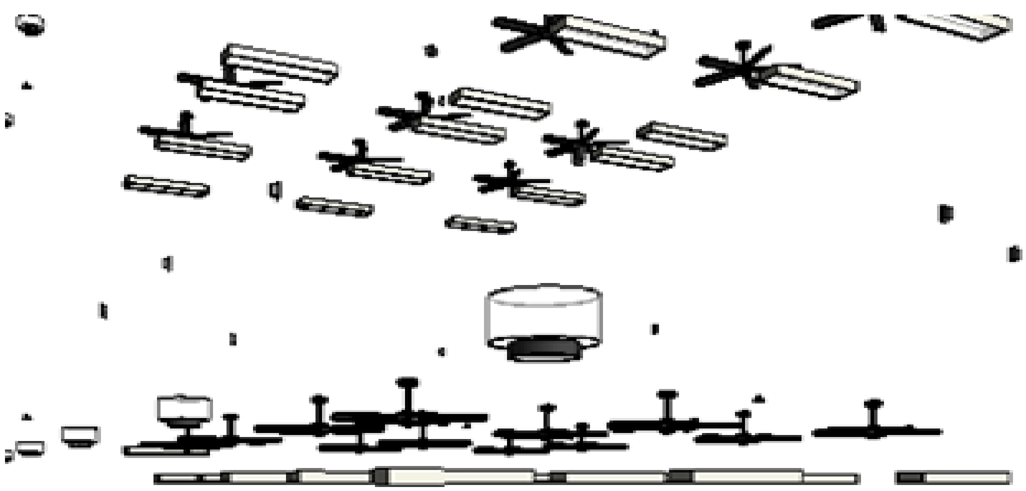


Figure 19: Electric fixtures and alarm devices 3D View

## 5.5 4D Simulation of the building:

Neviswork software was used for the simulation.

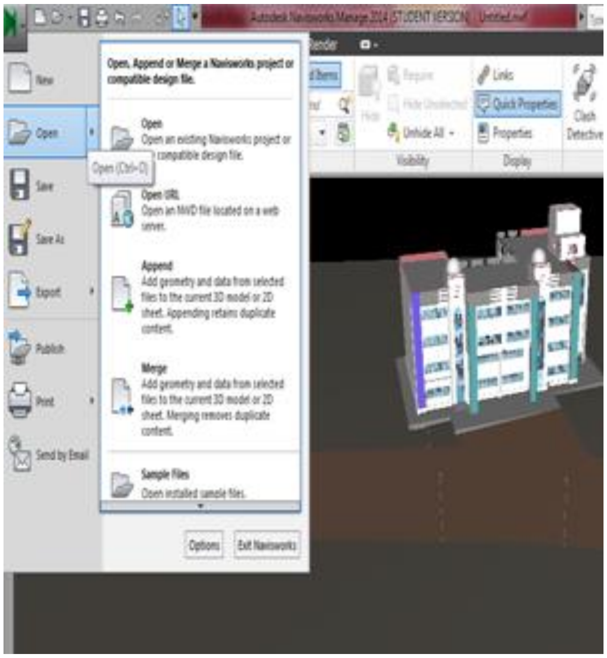



Figure 20: Importing Neviswork model

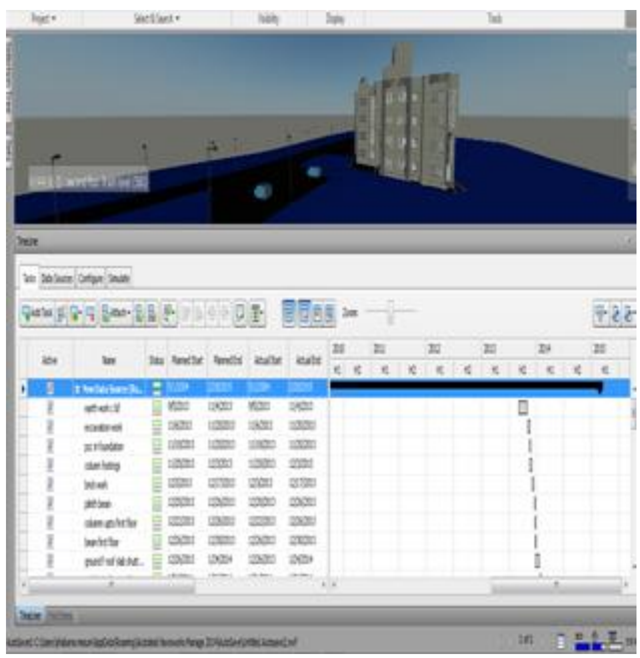


Figure21: Importing MS Project Schedule to Neviswork

## 5.6 4D SIMULATION ANIMATION CLIPS OF The Model

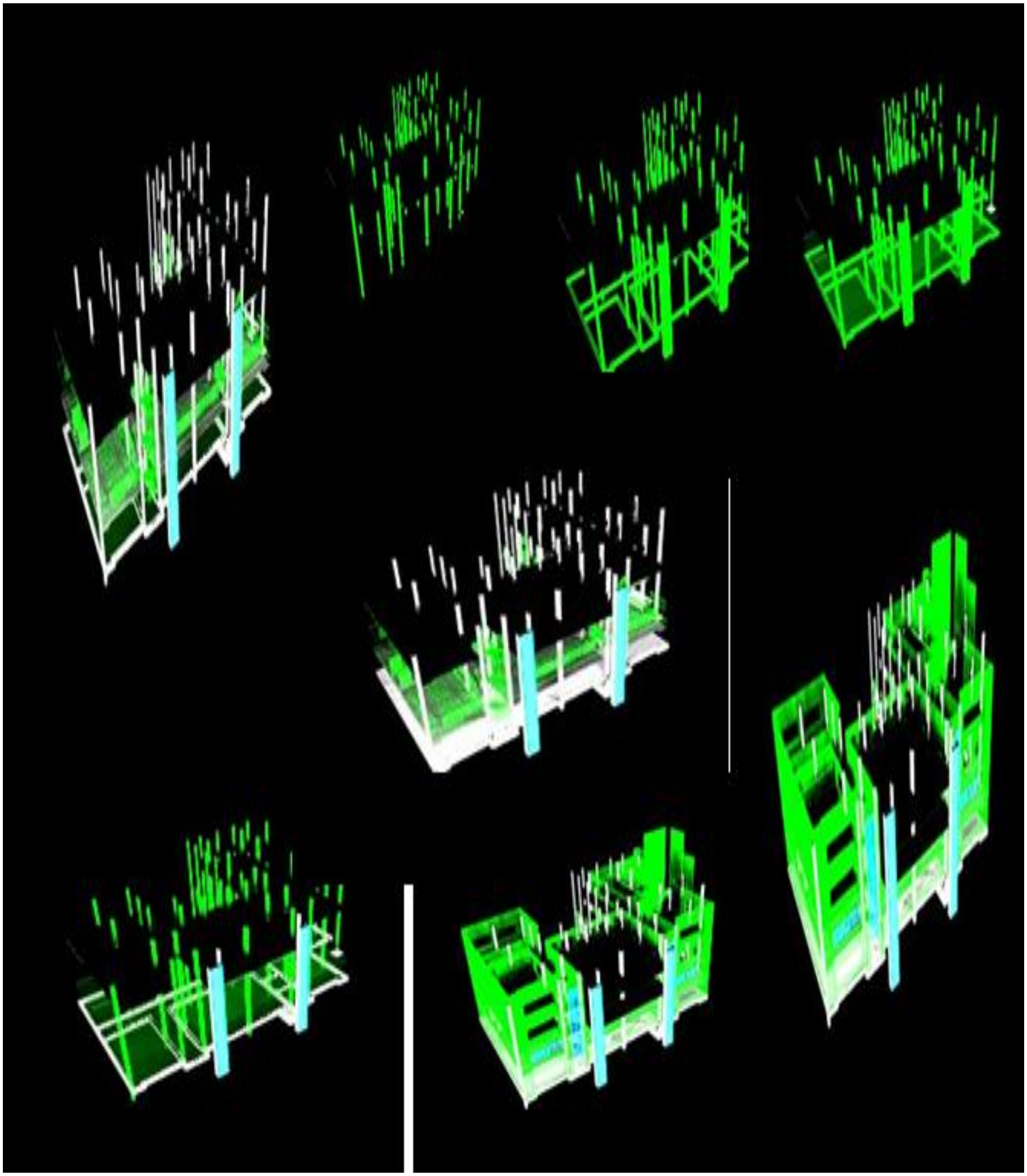


**Figure 22: 4D SIMULATION ANIMATION CLIPS OF The Model**

## 5.7 Quantity take off:

<Window Schedule>

| A | B | C | D | E |
|---|---|---|---|---|
| Family | Family and Type | Level | Height | Width |
| Aluminum_Exterior_Window_-_2_Wide_3886 | | | | |
| Aluminum_Exte | Aluminum_Exte | | 2' - 0" | 10' - 0" |
| Aluminum_Exterior_Window_-_2_Wide_3886: 8 | | | | |
| Casement with Trim | | | | |
| Casement with | Casement with | | 5' - 0" | 2' - 6" |
| Casement with Trim: 16 | | | | |
| Casement-1x2 with Trim-Casement-1x2 with Trim.rfa | | | | |
| Casement-1x2 | Casement-1x2 | ground finish floor | 19' - 0" | 3' - 6" |
| Casement-1x2 with Trim-Casement-1x2 with Trim.rfa: 2 | | | | |
| deslizar-4folhas | | | | |
| deslizar-4folha | | | 5' - 0" | |
| deslizar-4folhas: 28 | | | | |
| Sliding_Window_9296 | | | | |
| Sliding_Windo | | | 5' - 0" | |
| Sliding_Window_9296: 34 | | | | |
| Sliding_window_14931 (1) | | | | |
| Sliding_windo | Sliding_windo | | 5' - 0" | 17' - 6" |
| Sliding_window_14931 (1): 16 | | | | |
| Tpl Plain | | | | |
| Tpl Plain | Tpl Plain: Tpl Pl | | 5' - 0" | 7' - 6" |
| Tpl Plain: 8 | | | | |
| Grand total: 112 | | | | |

| | | |
|---|---|---|
| Brick, Common | | |
| | Brick, Common | 45712 SF |
| Brick, Common: 131 | | 45712 SF |
| Bronze, Architectural | | |
| Casement with | Bronze, Architect | 559 SF |
| Bronze, Architectural: 16 | | 559 SF |
| Cherry | | |
| | Cherry | 978 SF |
| Cherry: 20 | | 978 SF |
| Chrome | | |
| Double-Metal F | Chrome | 5 SF |
| Chrome: 3 | | 5 SF |
| Chrome Plating | | |
| Side_opening_ | Chrome Plating | 8 SF |
| Chrome Plating: 4 | | 8 SF |
| Concrete - Cast-in-Place Concrete | | |
| | Concrete - Cast-in | 35227 SF |
| Concrete - Cast-in-Place Concrete: 15 | | 35227 SF |
| Concrete Masonry Units | | |
| | Concrete Masonry | 37082 SF |
| Concrete Masonry Units: 98 | | 37082 SF |
| Concrete, Cast-in-Place - C50 | | |
| Basic Roof: Ge | Concrete, Cast-in- | 9626 SF |
| Concrete, Cast-in-Place - C50: 1 | | 9626 SF |

## 5.8 Clash detection in Neviswork:

Clash detection is the process of integrating these models together and identifying any inconstancies that need to be resolved

**Steps that were involved:**

- Imported models created in Revit to Neviswork manager
- Runned the software for the clash detection
- The test runs and shows the clash detection along with the 3d visualization**.**

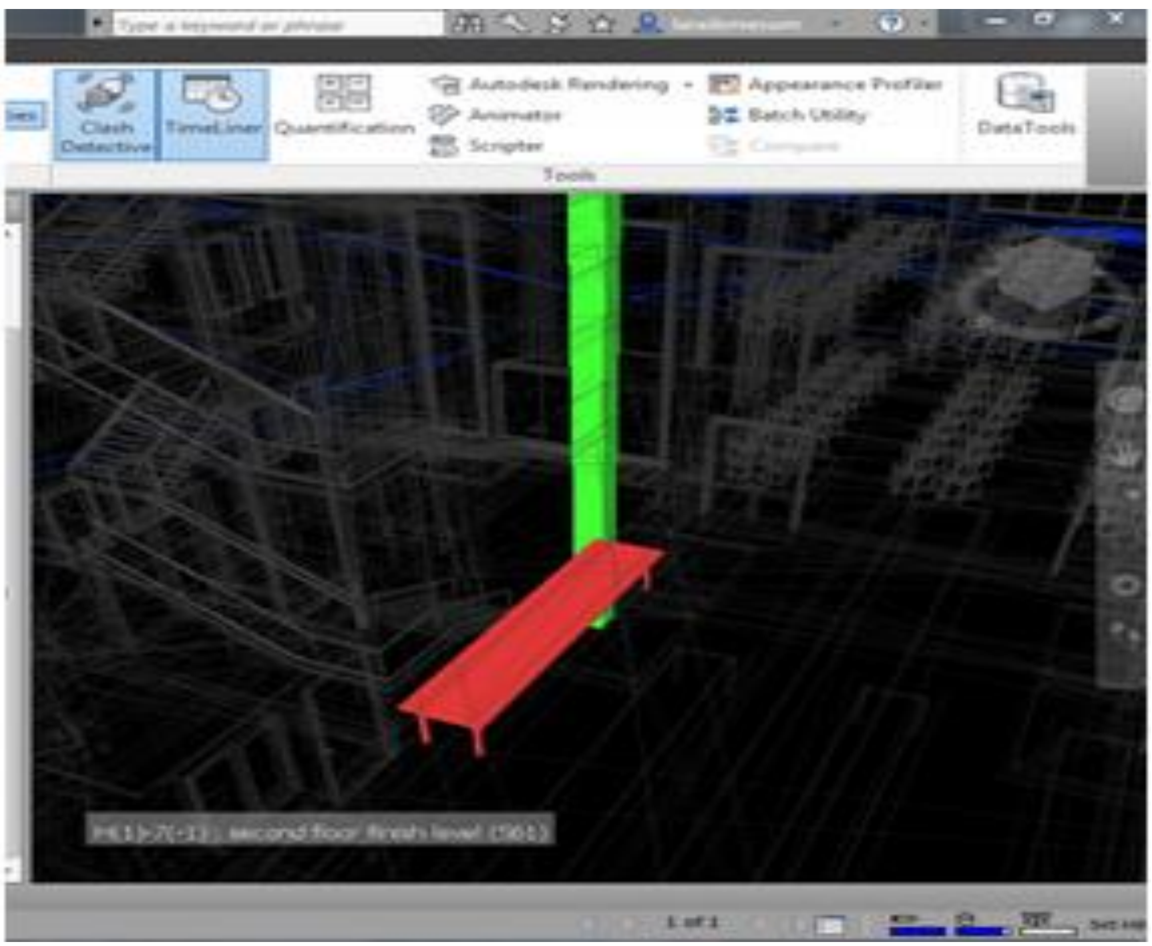



Figure 23: Clash detection result of third floor column and furniture

## 5.9 Energy Analysis:

Energy analysis of model was performed in Autodesk Ecotect Analysis software.

The complete results of energy analysis, building performance graphs, energy use graphs, energy fuel cost graphs and many more results were given in a PDF format. Some of the graphs and tables are shown below.

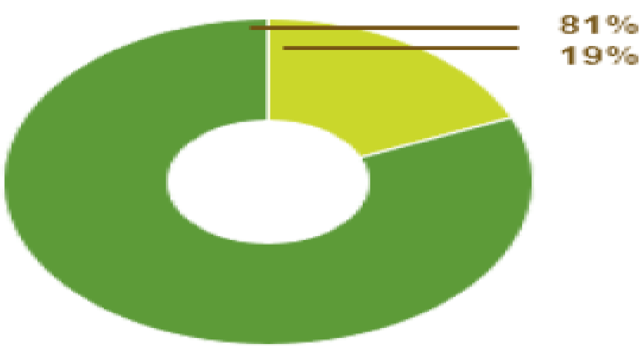
### Building Performance Factors

| | |
|---|---|
| Location: | Islamabad, Pakistan |
| Weather Station: | 53158 |
| Outdoor Temperature: | Max: 82°F/Min: -10°F |
| Floor Area: | 15,634 sf |
| Exterior Wall Area: | 12,402 sf |
| Average Lighting Power: | 0.99 W / ft² |
| People: | 372 people |
| Exterior Window Ratio: | 0.35 |
| Electrical Cost: | $0.09 / kWh |
| Fuel Cost: | $0.78 / Therm |

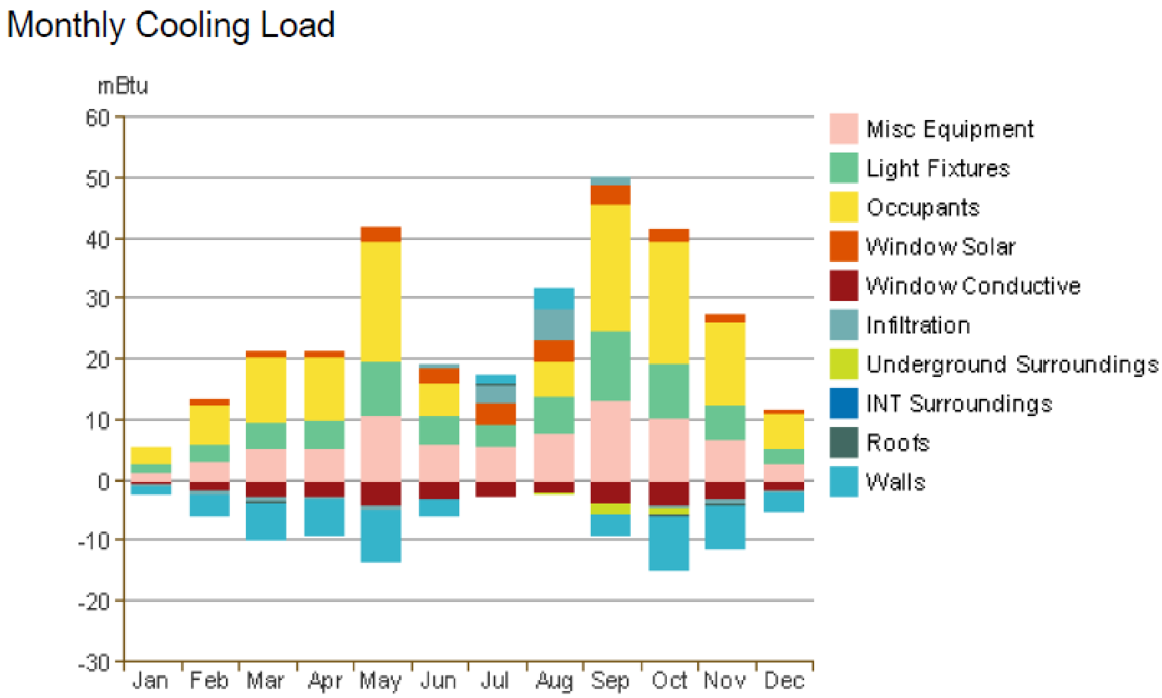
### Energy Use Intensity

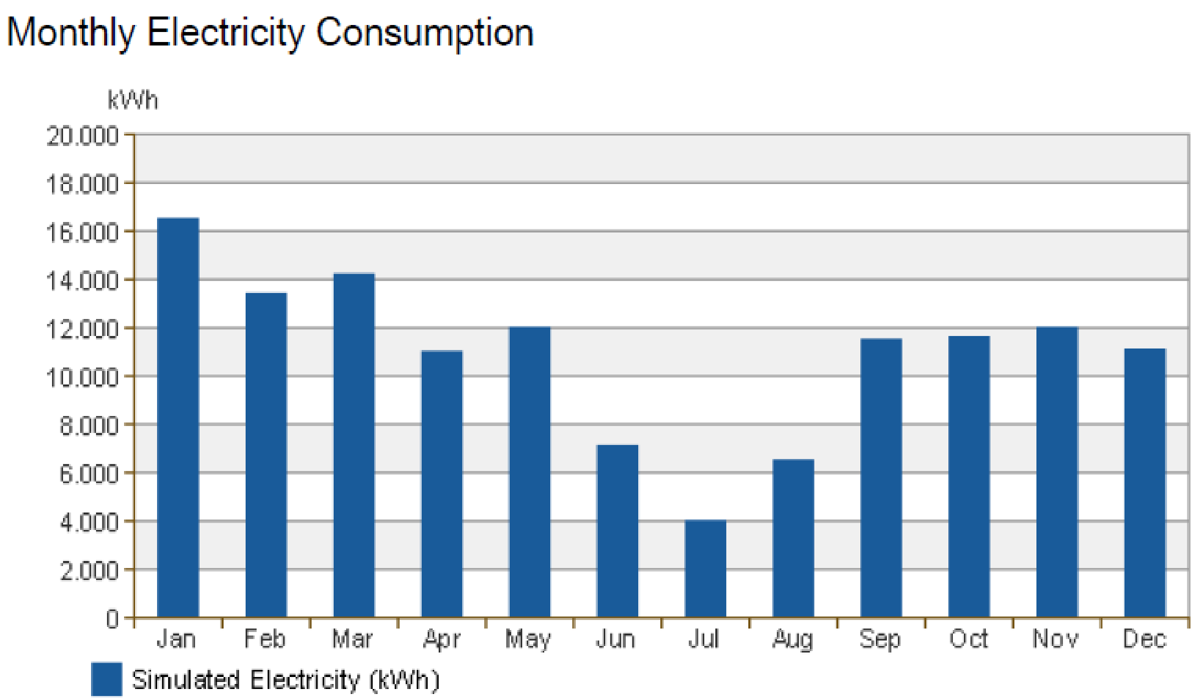
| | |
|---|---|
| Electricity EUI: | 7 kWh / sf / yr |
| Fuel EUI: | 106 kBtu / sf / yr |
| Total EUI: | 131 kBtu / sf / yr |

### Annual Energy Use/Cost




| | | | | |
|---|---|---|---|---|
| Electricity | 19% | $12,298 | 130,969 | kWh |
| Fuel | 81% | $15,382 | 19,626 | Therms |
| | | $27,680 | | |


Monthly Cooling Load
mBtu
60
50
40
30
20
10
0
-10
-20
-30
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Misc Equipment
Light Fixtures
Occupants
Window Solar
Window Conductive
Infiltration
Underground Surroundings
INT Surroundings
Roofs
Walls


Monthly Electricity Consumption
kWh
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Simulated Electricity (kWh)

# 6. Facility Management:

Facility management is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology

Rapid advances in BIM offer new opportunities to improve FM processes and enhance the use of project information, not only during design and construction, but also throughout project's life cycle. There are some pioneering organizations pushing the use of BIM, but industry-wide adoption of BIM in FM has not been embraced yet.

## 6.1 Traditional methods of FM:

- Facility management is done manually.
- Drawing sheets are used to know about the space management and other facilities.
- CAD files are also used that cannot be updates if any changes are done in the plan.

## 6.2 BIM Uses For facility management:

- BIM helps in Locating Building Components and to perform preventive and corrective maintenance, FM personnel regularly need to locate building components(equipment, materials, and finishes) and related information for prompt problem detection and resolution. Conventionally, on-site FM personnel rely on paper-based blueprints or on their experience, intuition, and judgment in finding and locating building equipment such as HVAC systems and electrical, gas, and waterlines, which are located in places not readily visible such as above the ceilings, behind the walls, or under the floors. Locating the equipment is a repetitive and time- and labor-consuming task for either the repair technician or the equipment manager. Locating equipment becomes critical especially during an emergency, BIM facilitate in it and helps in locating the building components in less time. BIM models to see where the mechanical, plumbing, and electrical components are.
- It plays an important role in Visualization and Marketing. The importance of BIM's visualization and coordination capabilities has been discussed and assessed in different construction projects. With its three-dimensional graphical interface and ability to

integrate material texture, light sources, landscaping, and so on, BIM provides improved visualization of the space to facility managers during design and construction of renovations and remodels.

- BIM facilitate in Checking Maintainability. Maintainability is defined as the ability to achieve optimum performance throughout the life span of a facility with a minimum life cycle cost. Initial capital costs and schedules are given priority in most projects, ignoring the fact that over the whole life cycle the biggest costs come from operation and maintenance. One of the more important tasks of the delivery process of a facility is to minimize the total facility-related cost in use.
- BIM helps in Creating and Updating Digital Assets. After the building commissioning is completed, digital assets are manually created or uploaded to the facilities management systems(FMS) to support FM functions such as work order management, maintenance and repair management, and so on. It is critical to have digital assets in electronic formats with proper nomenclature and organization to simplify access and distribution so that they are easily retrievable and traceable. Creating digital assets in BIM helps in management.
- BIM helps in controlling and managing energy.Through energy analysis we can know which component of building is resulting in hotness and cooling of the building. In addition, linking BIM with building sensors and metering and sub metering information real-time monitoring and automated control can be done..
- In fire and emergency cases, it can be used to locate the building elements and emergency routes in short time.
- Space management can be handled
- Electrical. Mechanical and sanitation operations and maintenance.

### 6.3 Online Survey

The online survey was designed to target a wide range of FM professionals and to determine the respondents' level of awareness, experience, and interest regarding the application of BIM in FM. The goal of the survey was to answer the following key questions:

- To what extent is BIM currently implemented in FM?
- What are the plans of FM organizations for adopting BIM in the future?
- What are the areas where BIM could bring value to the FM organizations?

The survey was hosted on https://new.qualtrics.com/ through an account funded by USC's Viterbi School of Engineering.

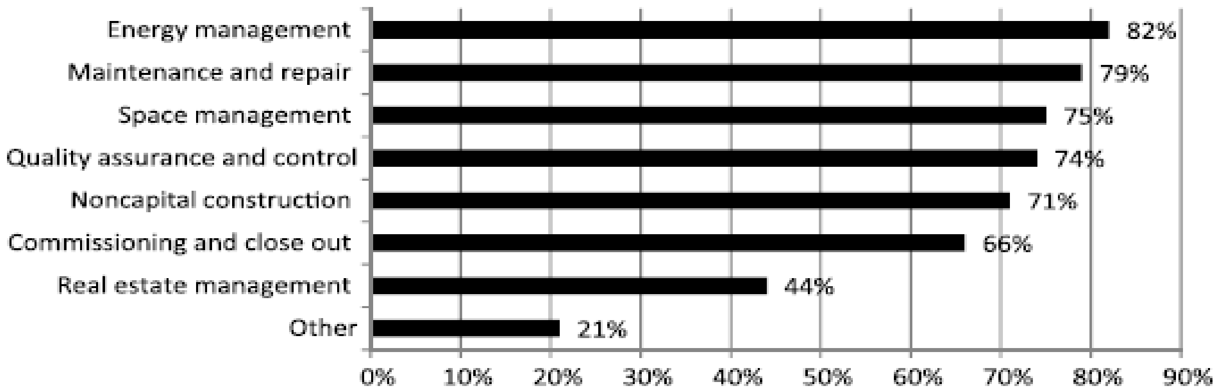



figure 24: Organizational functions

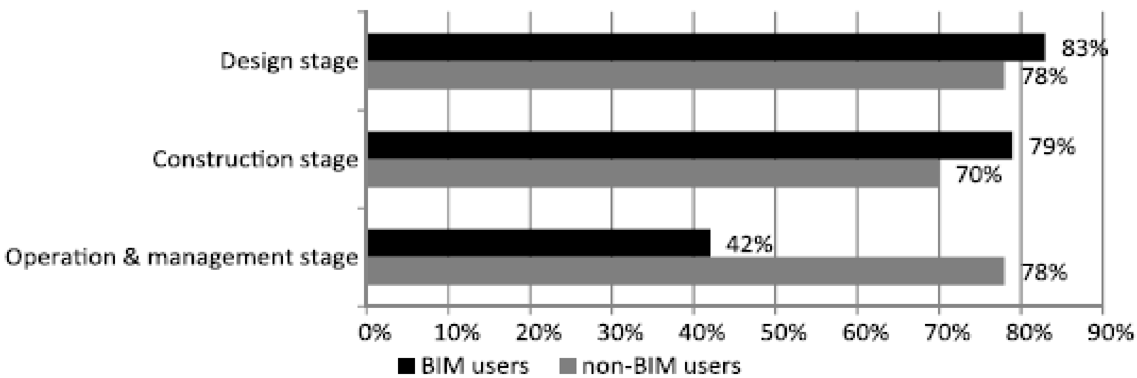



Figure 25: Project stages that BIM is currently used for or is planned to be used for facility management

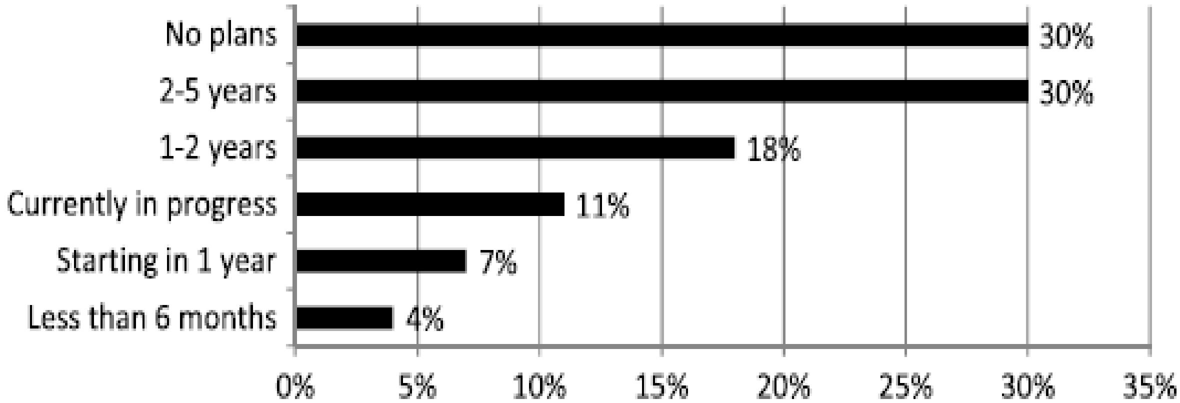



**Figure 26: Non-BIM user organizations' plans to implement BIM**

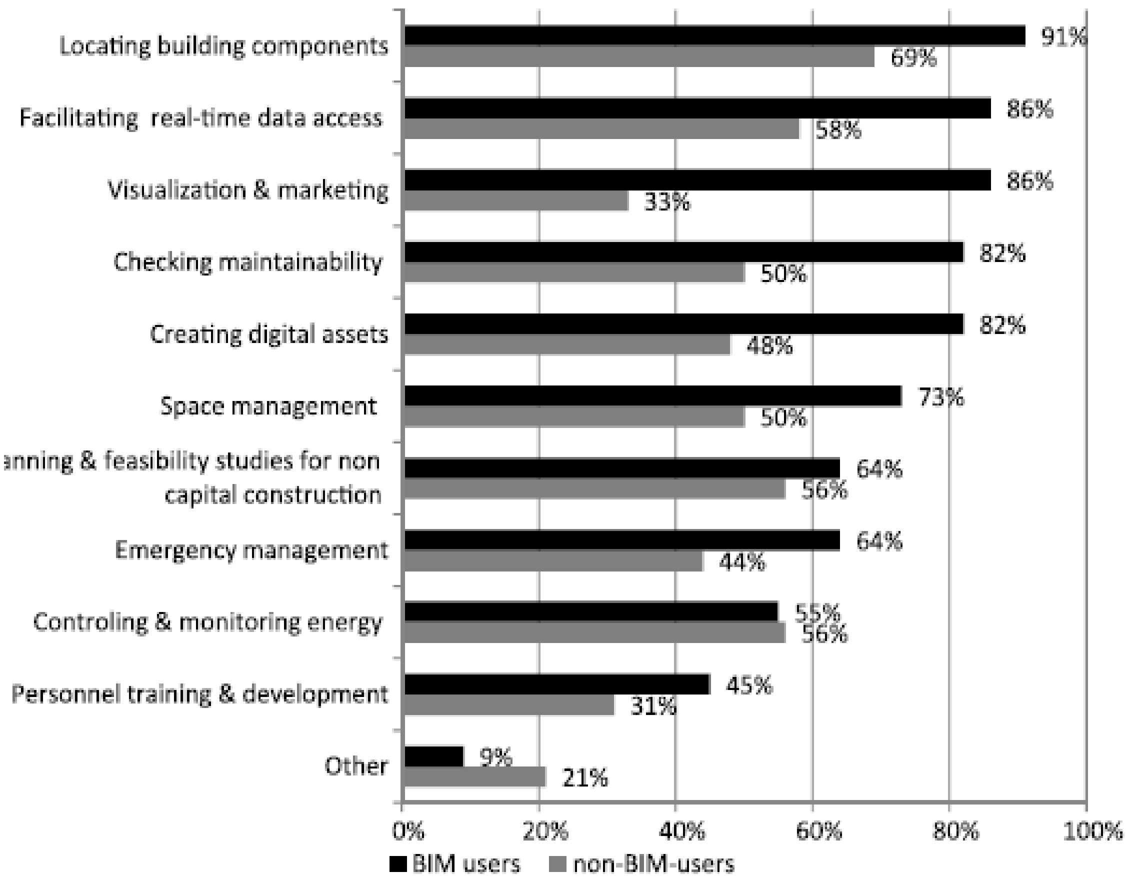



**Figure 27: Potential FM application areas that BIM can be used for**

## 6.4 Relationship between various BIM applications and facility management:

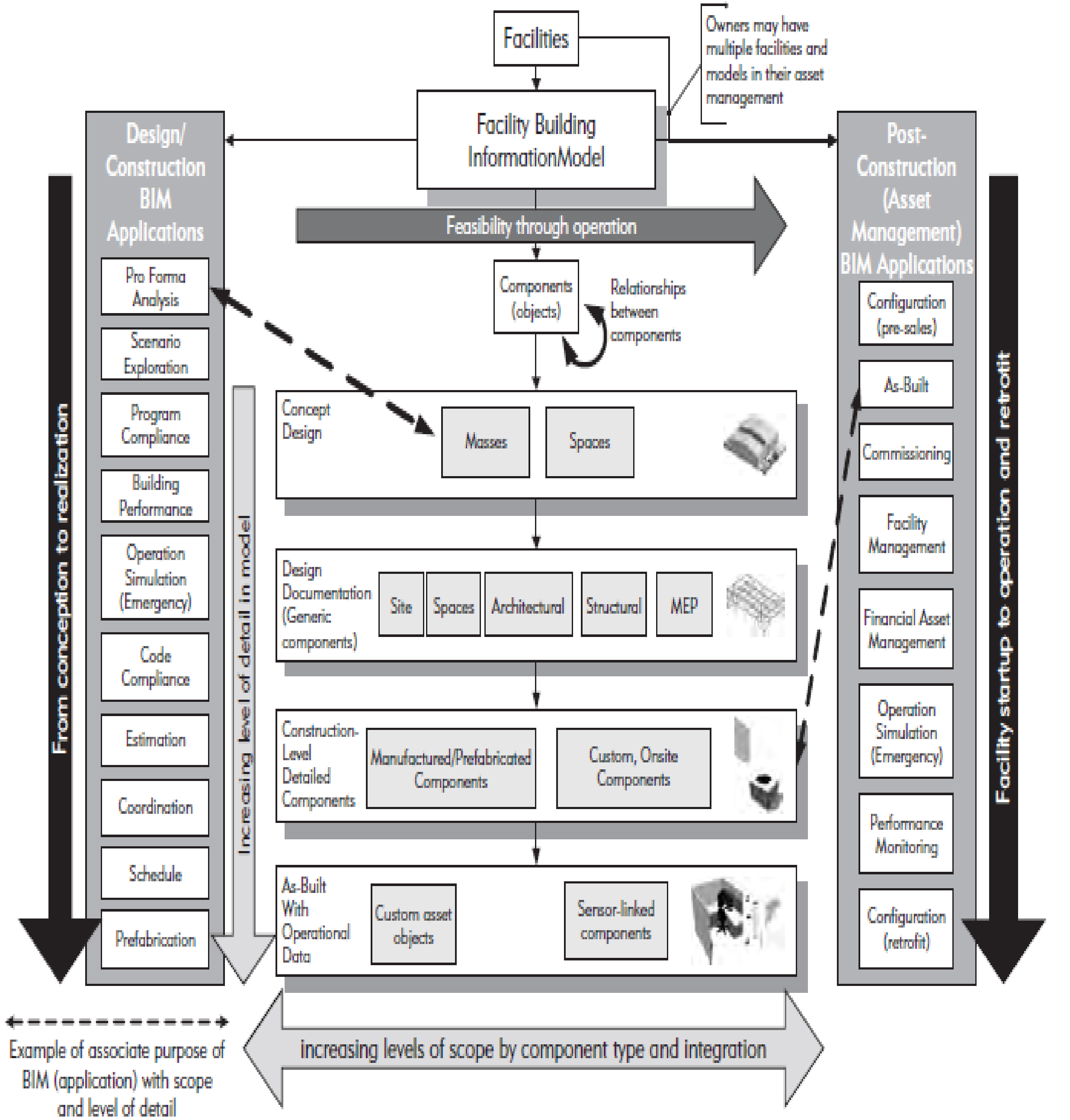



**FIGURE 4-18 Conceptual diagram showing the relationship between various BIM applications during the facility delivery process; post-construction and their relationship to the level of scope and detail in the model.**

## 6.5 A Case Study of Using BIM and COBie for Facility Management by Sarel Lavy and Salil Jawadekar

The paper investigates the use of Building Information Modeling (BIM) and Construction Operations Building Information Exchange (COBie) for facility management on a project where implementation concepts were used.

- University, Main Building Texas A&M University, College Station, TX
- Owner: University System
- Construction cost: $30 Million
- Area: 90,300 GSF

We selected this case study because the study was conducted in a university campus building which was constructed for educational purpose.

The building houses classrooms, the university library, a multipurpose science laboratory, a dining facility, a bookstore, and administrative and faculty office spaces.

### 6.5.1. Steps used to generate database for management of facilities in building:

#### Phase 1:

Use of Information Industry Classes (IFC) for formatting various BIM model created during design and construction phase.

#### Phase 2:

Extracting the information from the IFC formatted BIM files into a COBie based Microsoft spreadsheet

Import the Microsoft spreadsheet into Computerized Maintenance Management System (CMMS)

### 6.5.2. Results of the case study:

- The  project was  90% successful in the application of the second phase
- The project could not accomplish the first phase, because of the fact that both the architect and the contractors had no contractual obligation to format their BIM models or other forms of data in a specified manner.
- Reduced the operations and maintenance (O&M) contract costs from incomplete equipment inventories. An accurate equipment inventory can reduce O&M contracting costs from 3% to 6% by identifying and tracking facility equipment and facility square footage
- Reduce costs of re-documenting "as-built" conditions and field surveys for building renovation projects.
- According to the facility managers, the cumulative saving in time responding to a work order will average 11.6 minutes per work order, or 8.7% time saving.

## 6.6  How facility management is done in NUST?

We conducted a survey and asked different questions related to How facility management is done in NUST.

- They use manual drawing sheets, cad files throughout the maintenance and repair phase that are tedious for them to carry.
- Similarly the Cad files are not updated if there is any change in the facility
- Emergency system are installed but they are not updated..
- In the main building in CIPS they are using Building Management System that is a good step towards modern facility management.
- They are also interested in using BIM in their construction phase and for the facility management too.

## 7. AREA OF APPLICATION (PRACTICAL APPLICATION)

The model we created can be used by the management team of the building to manage and do maintenance and repair of the facilities in building during operation. The sustainability of different materials used in the building can also be measured by using the model of the building. The 5D model can be used by the related authorities to make amendments, improvements in case of renovation of building in future. Data gained by energy analysis simulation of the model can help the users to manage the cost to be used for lightening, cooling and heating of the building.. The user can use data in the BIM model of the building to monitor building performance and verify how well the building performs as compared to the model and use the result for similar constructions in future. The 3D model of the building can be used by the interior designer and fabricator to utilize the space of building efficiently.

## 8. CONCLUSION:

BIM models should incorporate all information necessary to create the deliverables during the building projects' lifecycle. There are various levels and depths to creating 3D building models starting from mass models used for schematic design through 3D models created for visualization purposes to intelligent building information models. While models created for visualization only contain no more than the 3D geometry and material descriptions. To create an intelligent building information model, an abundance of additional information necessary to coordinate, document, list and manage the model and data is required.

## RECOMMENDATIONS:

- BIM require training and a lot of knowledge. So training and education on BIM should be given by the engineering institutes. Software used to implement BIM are necessary to learn, so building information modeling educational programs should be arranged. Highly interactive programs should be arranged by the institute to train the students and related organization. Education on BIM should be included in the course of engineering and architecture students.
- The model we created was completion of first phase for the steps required to generate a facility management system.so we recommend the students intended to work on facility management and BIM to use the model and along with some software students generate a database to extract and store the data from the model.then link the database and the model to get a complete facility management system.

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